Ventilator Graphics: Optimizing Ventilator Settings

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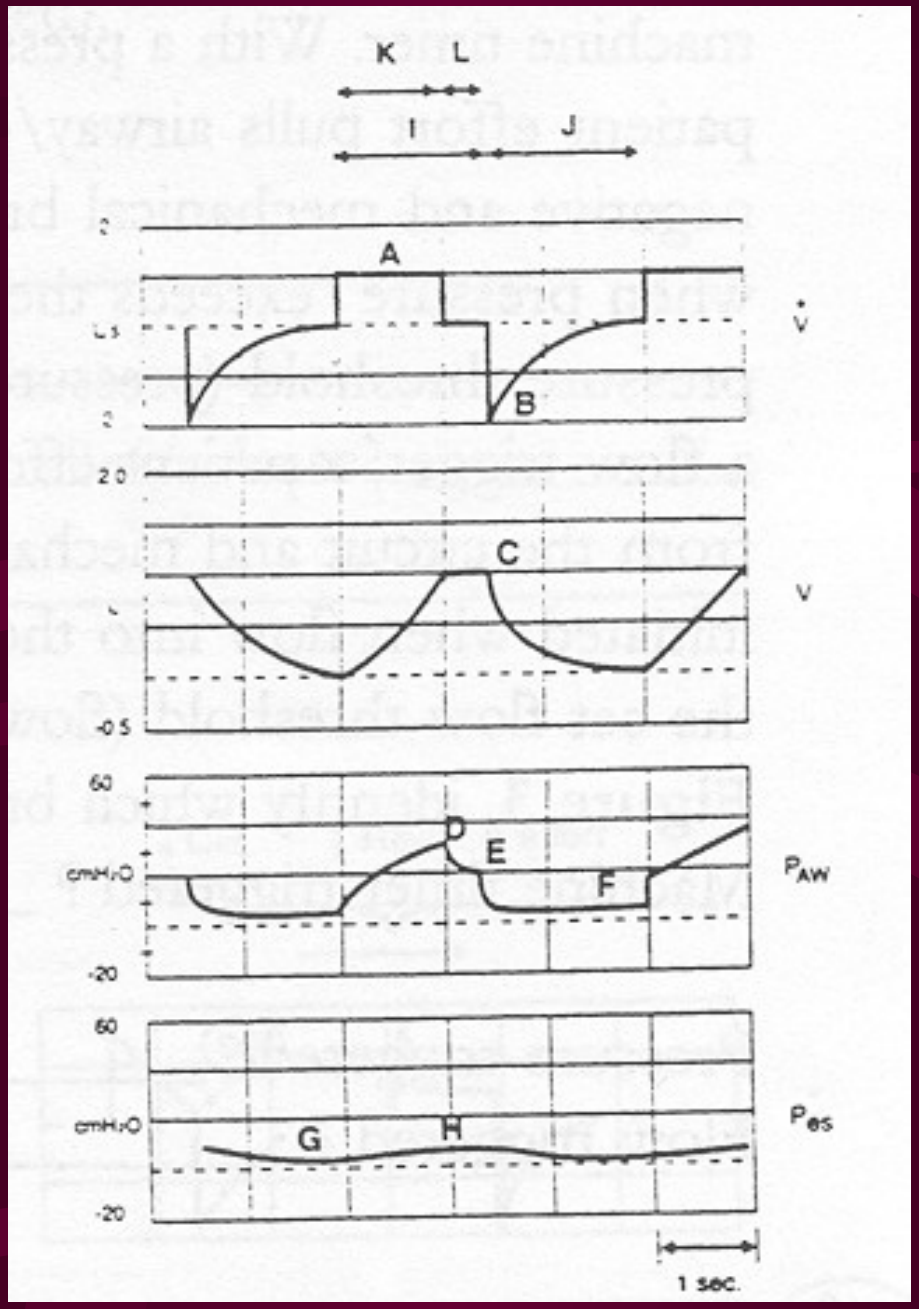
PCCMS

Overview

- Graphical Assessment
- Calculating Loads
- PEEP
- Ventilator Dysynchrony

Graphical Displays

- Four Parameters commonly monitored
  - pressure
    - Ventilator circuit (Paw)
    - Esophagus (Pes) --pleural pressure
  - flow
  - volume
  - time
- Commonly plotted as pressure, flow, and volume over time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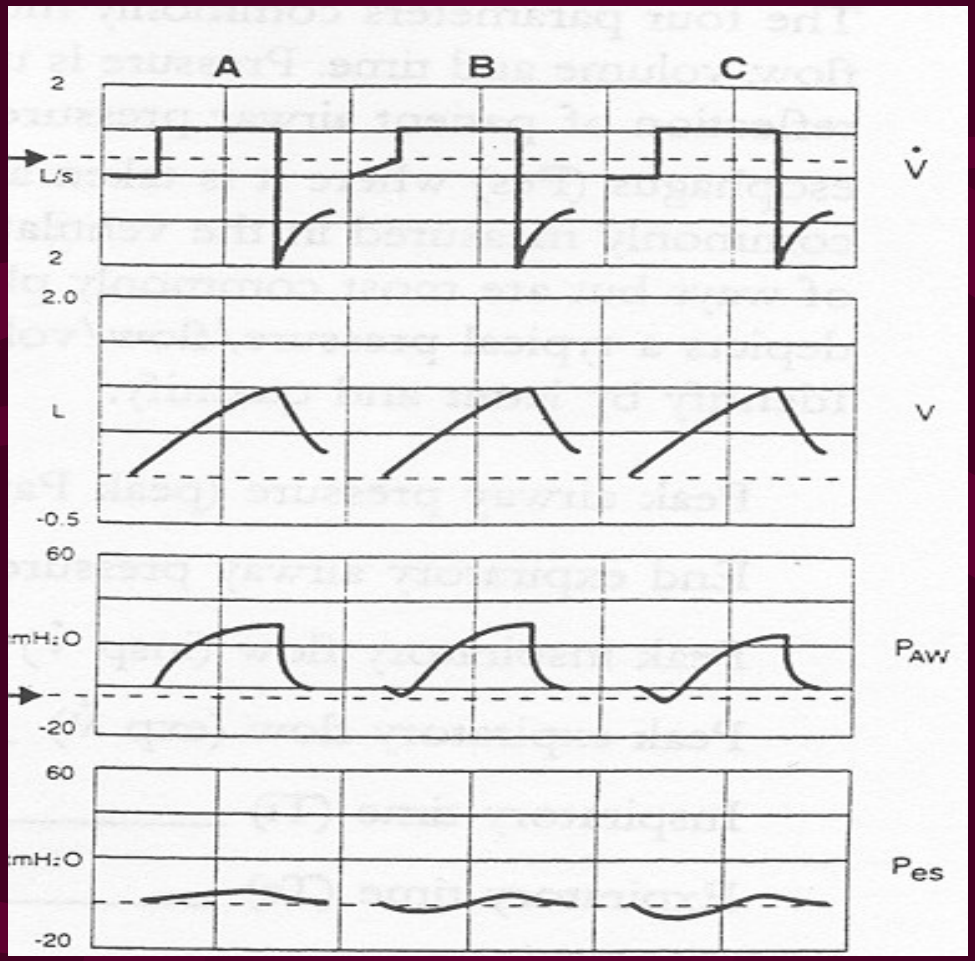
1 sec.

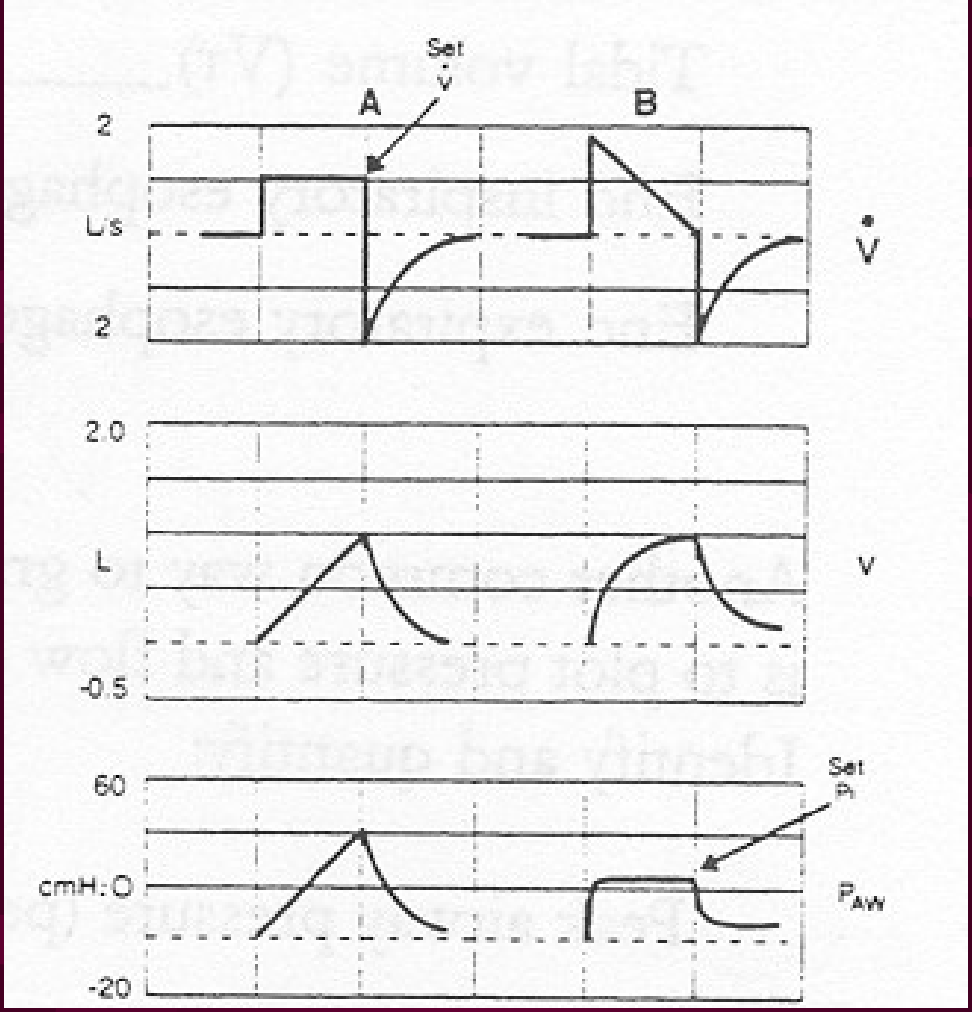
Breath Delivery

- Four phases of ventilatory cycle
  - trigger
  - flow delivery
  - cycle
  - expiratory phase
- Breaths described by what determines the above phases

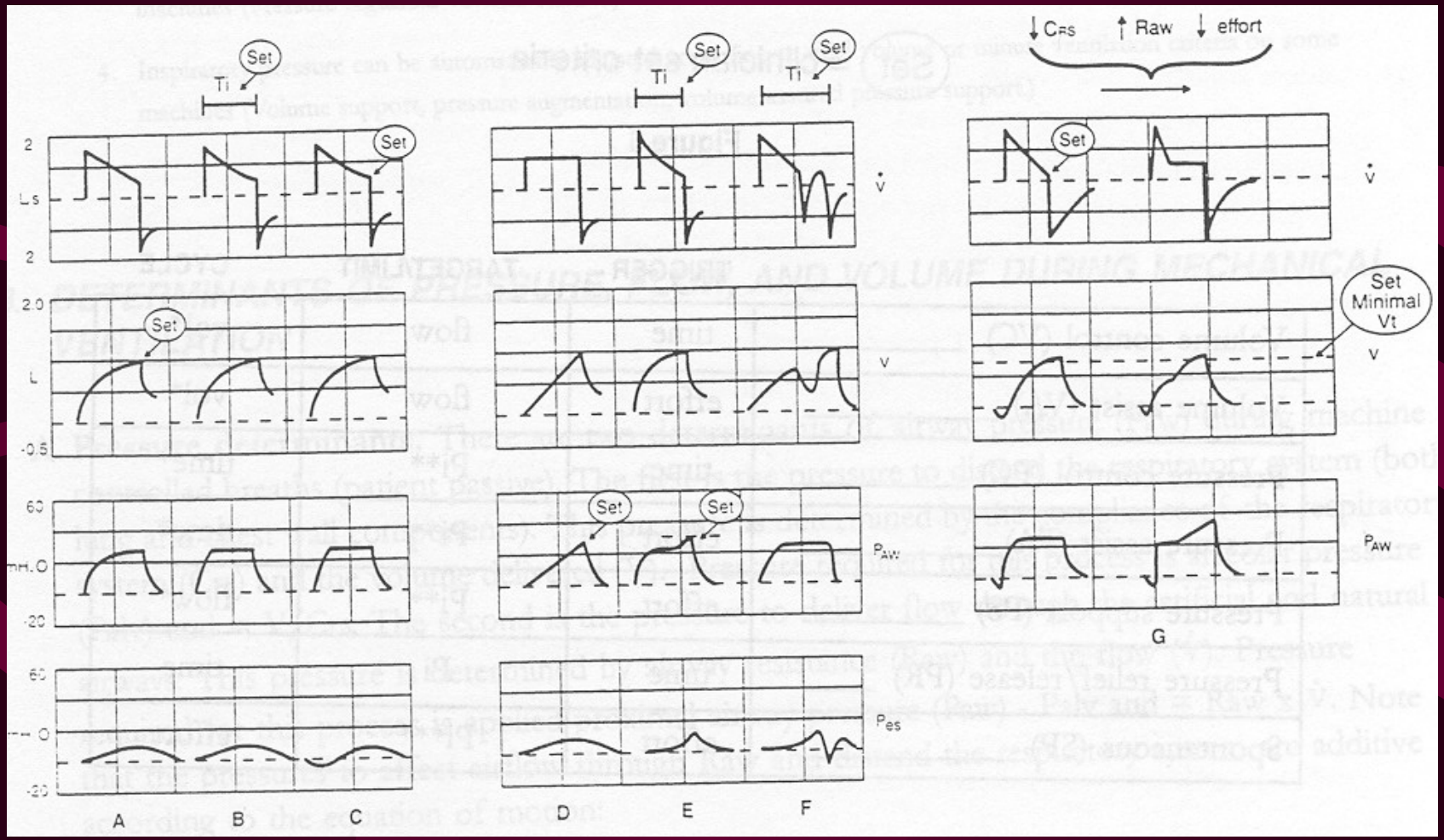
Triggers



Flow



Cycling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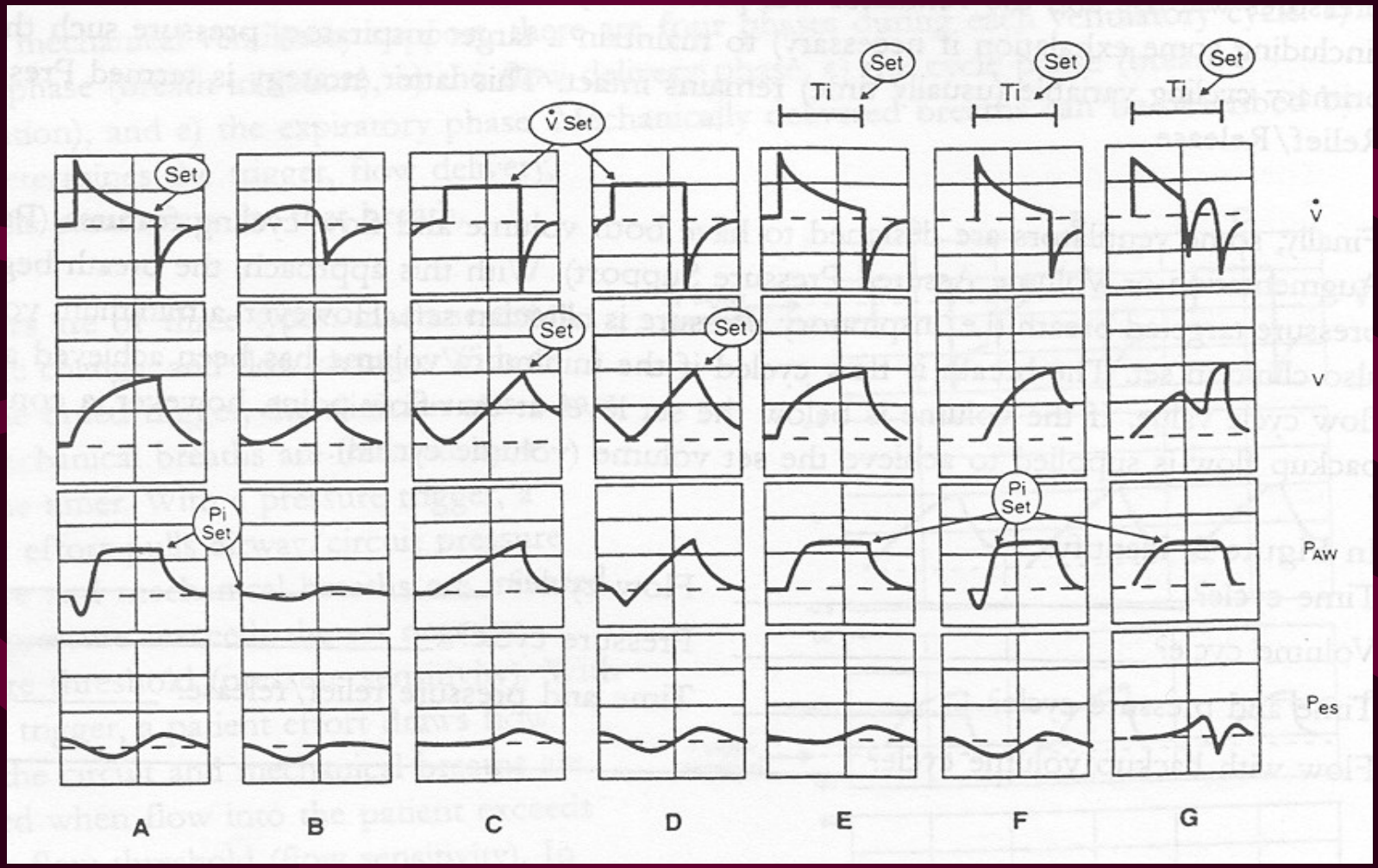
Breath Types

	TRIGGER	TARGET/LIMIT	CYCLE
Volume control (VC) _____	time	flow	vol*
Volume assist (VA) _____	effort	flow	vol*
Pressure control (PC) _____	time	Pi**	time*
Pressure assist (PA) _____	effort	Pi**	time*
Pressure support (PS) _____	effort	Pi**	flow*
Pressure relief/release (PR) ____	time	Pi	time
Spontaneous (SP) _____	effort	Pi***	effort

Breath Types



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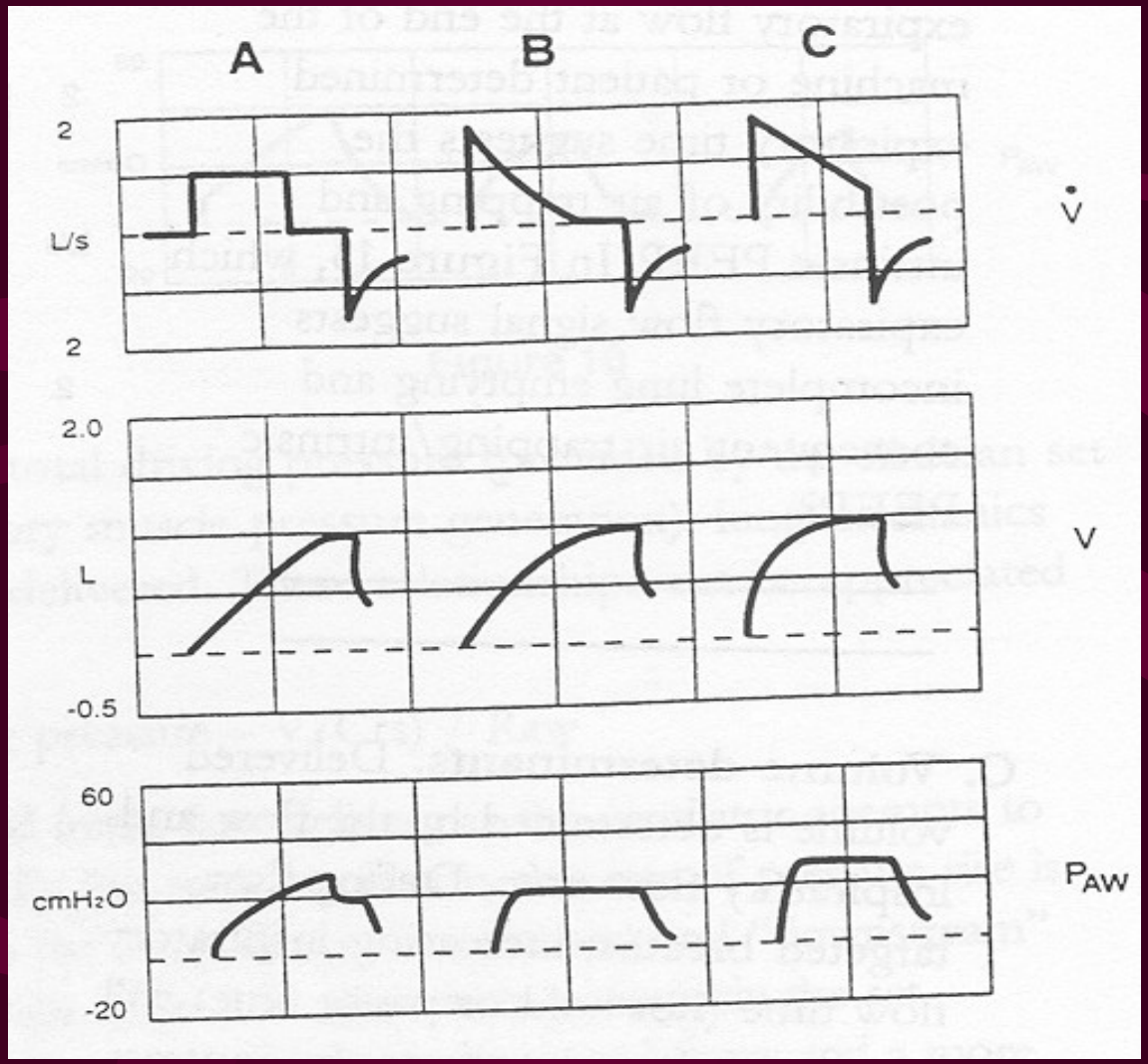
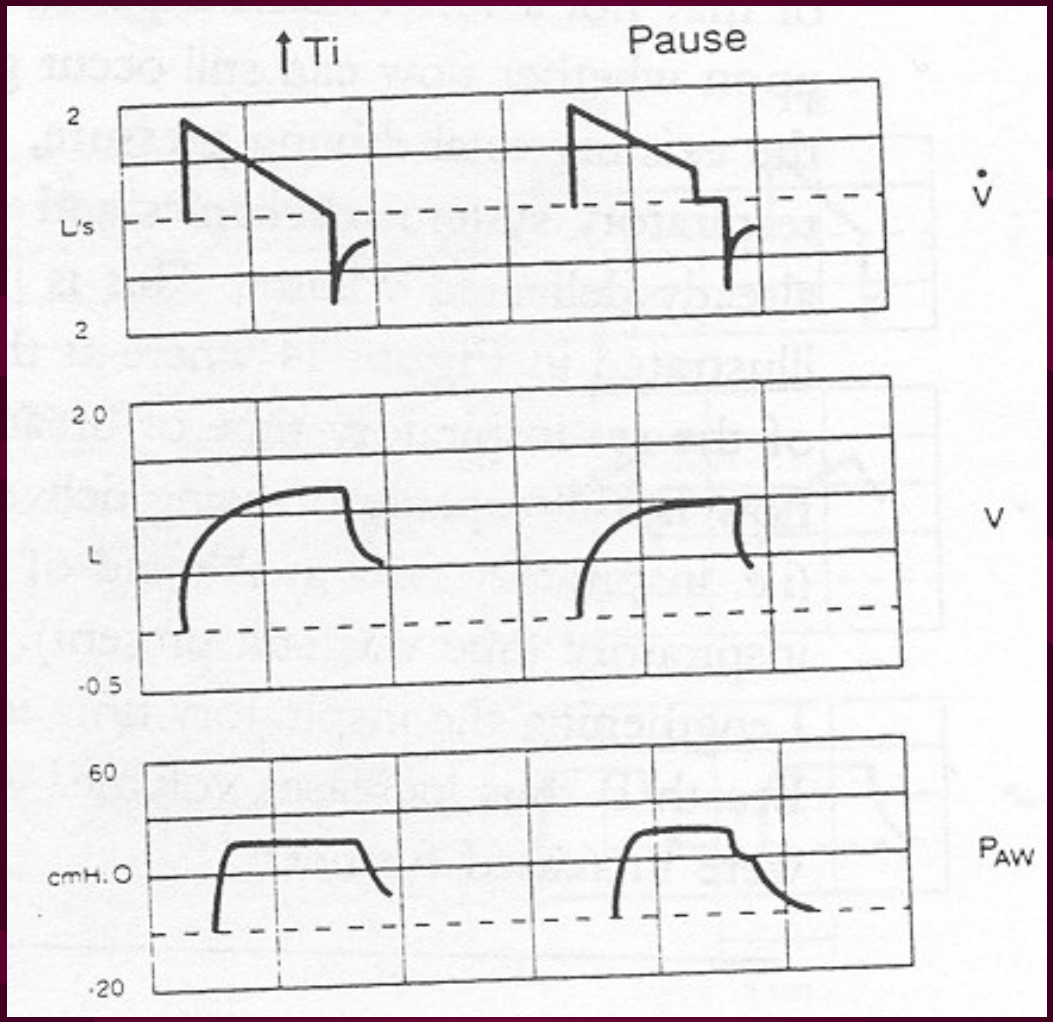
Plateau Pressure

- Lung “overstretch” has been linked to VILI
- An approximation of lung stretch is the “end inspiratory” pressure
- Must be measured in a “no flow” state

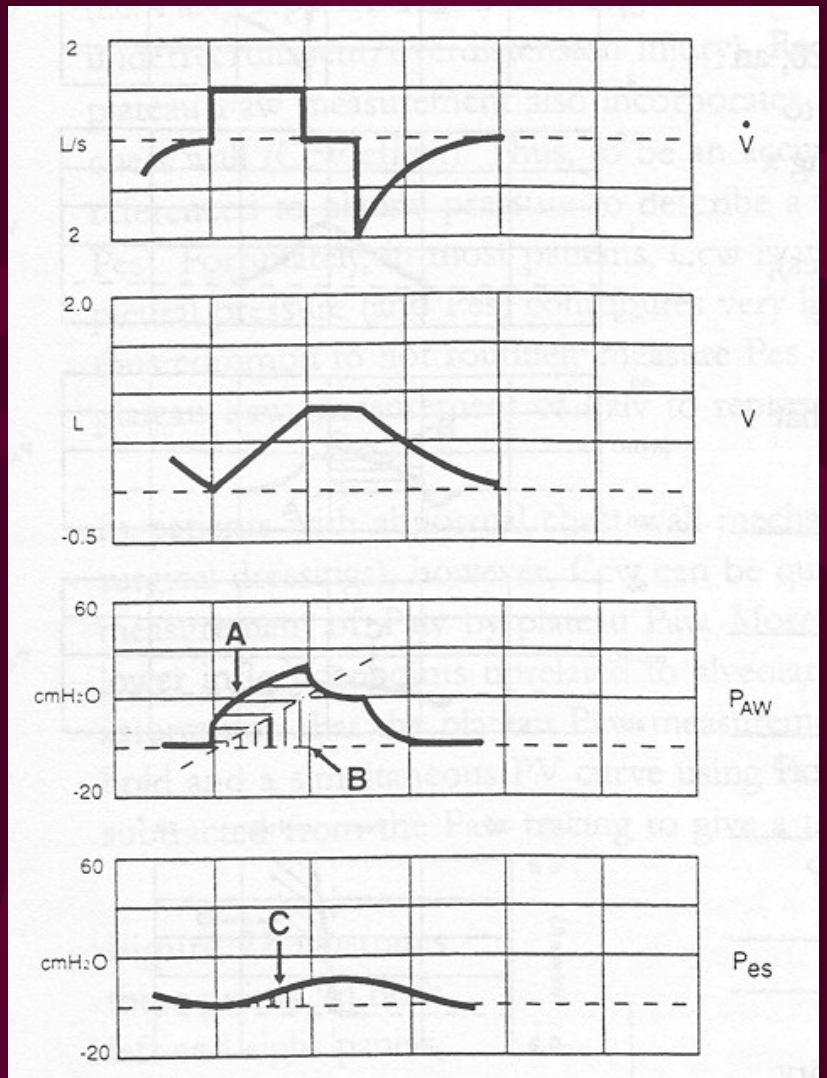
Plateau Pressure



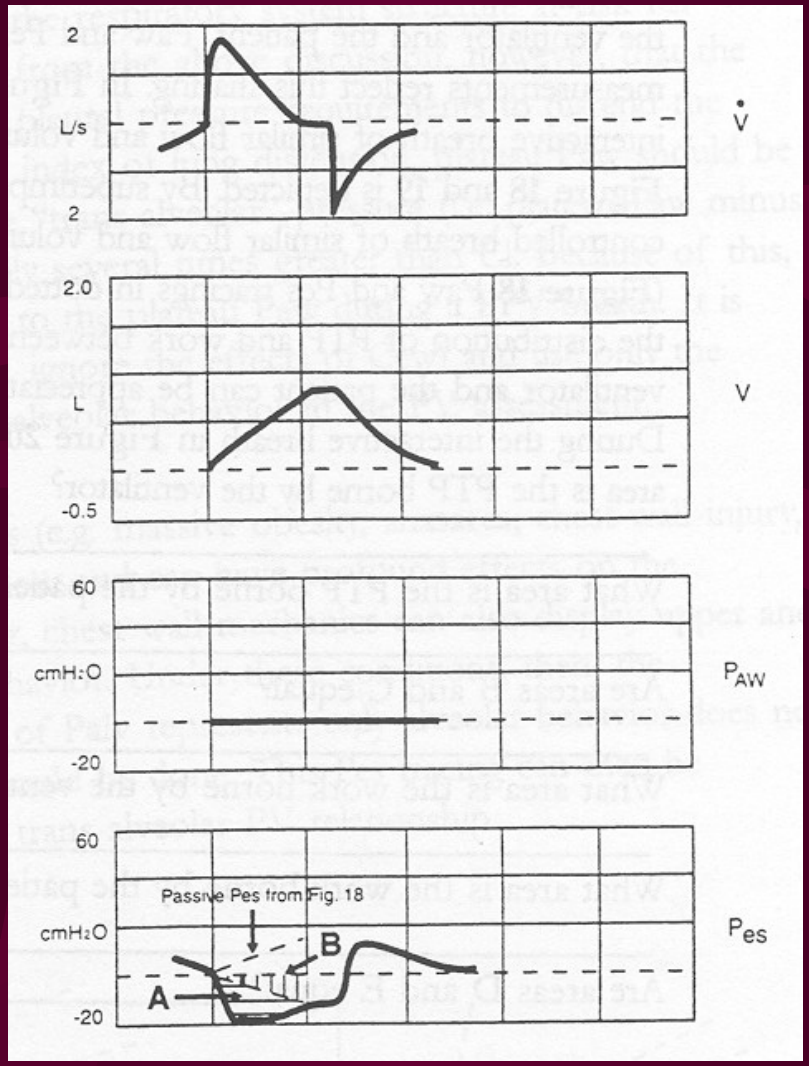
Plateau Pressure



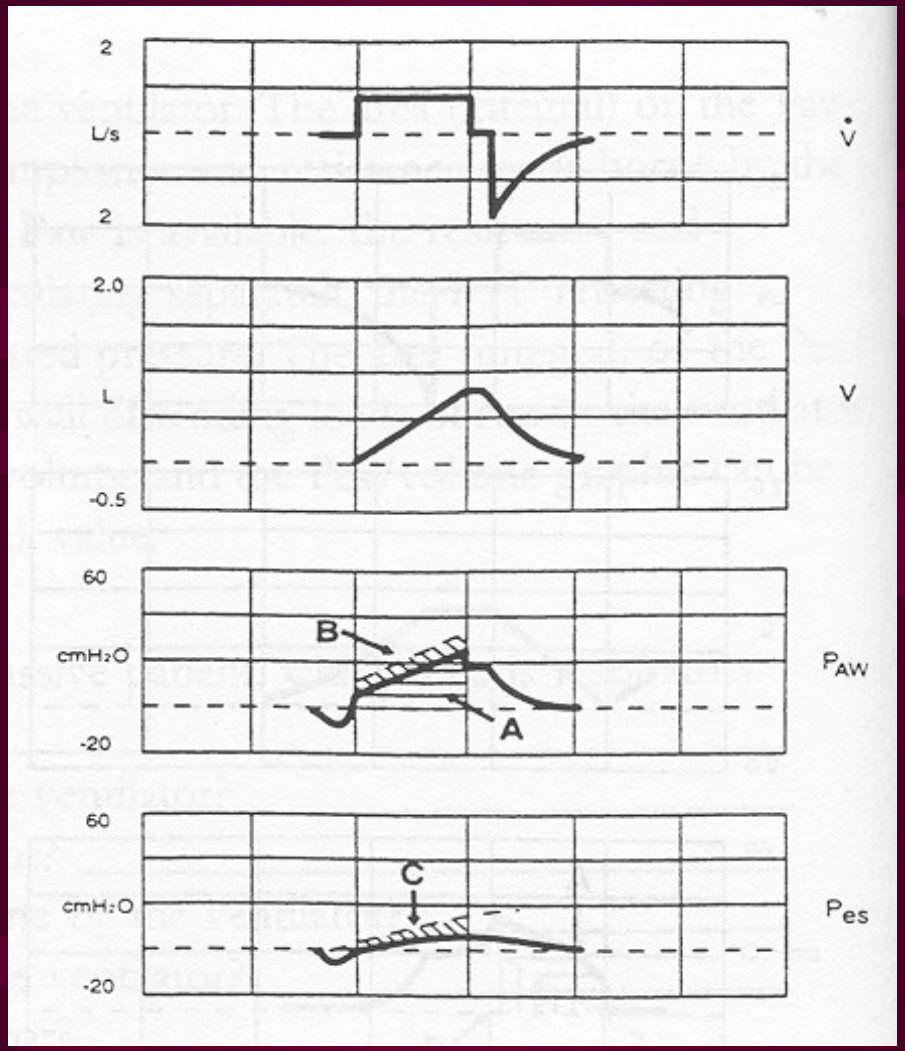
Measuring Loads



Measuring Loads



Measuring Loads



Overview

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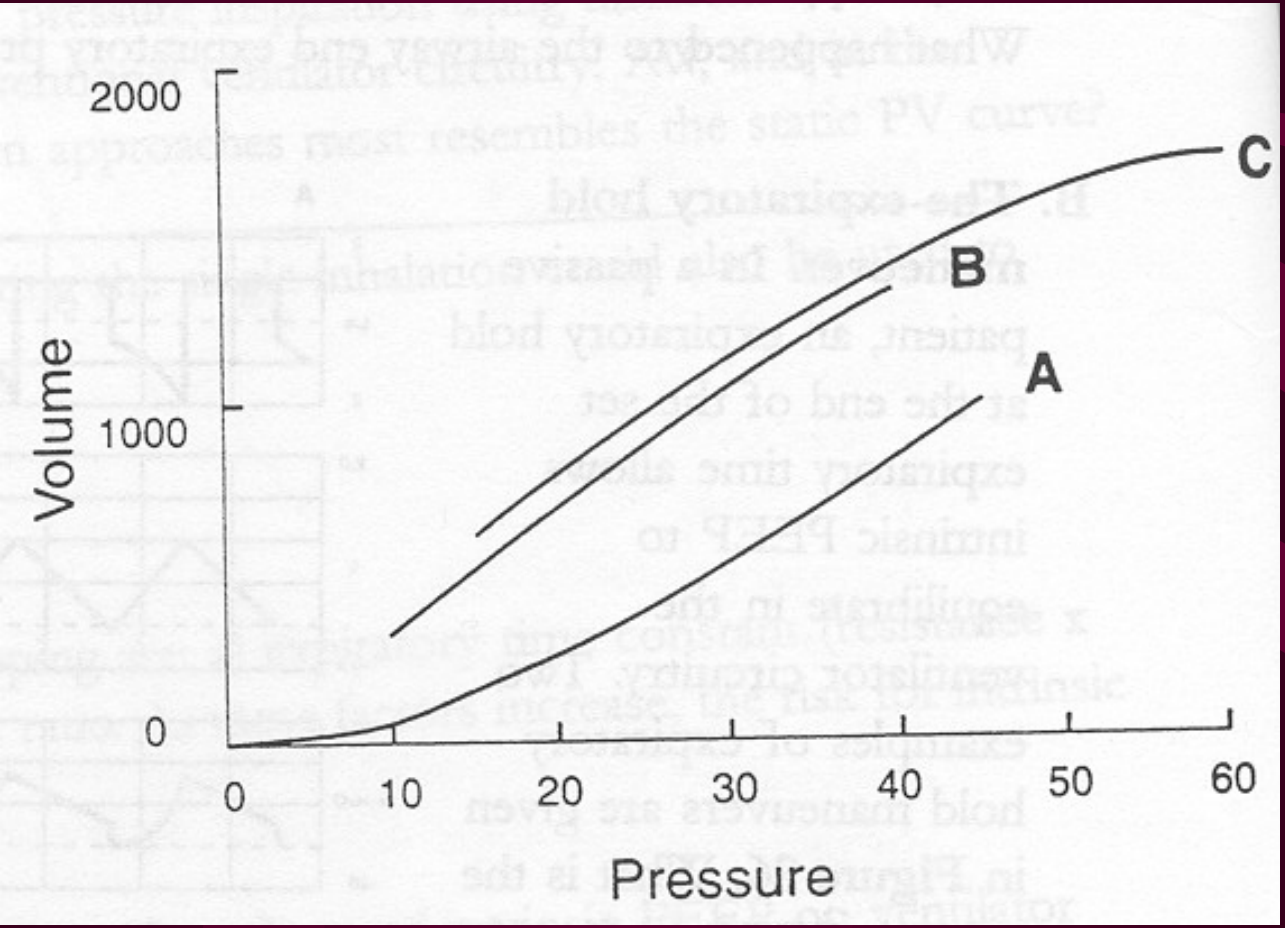
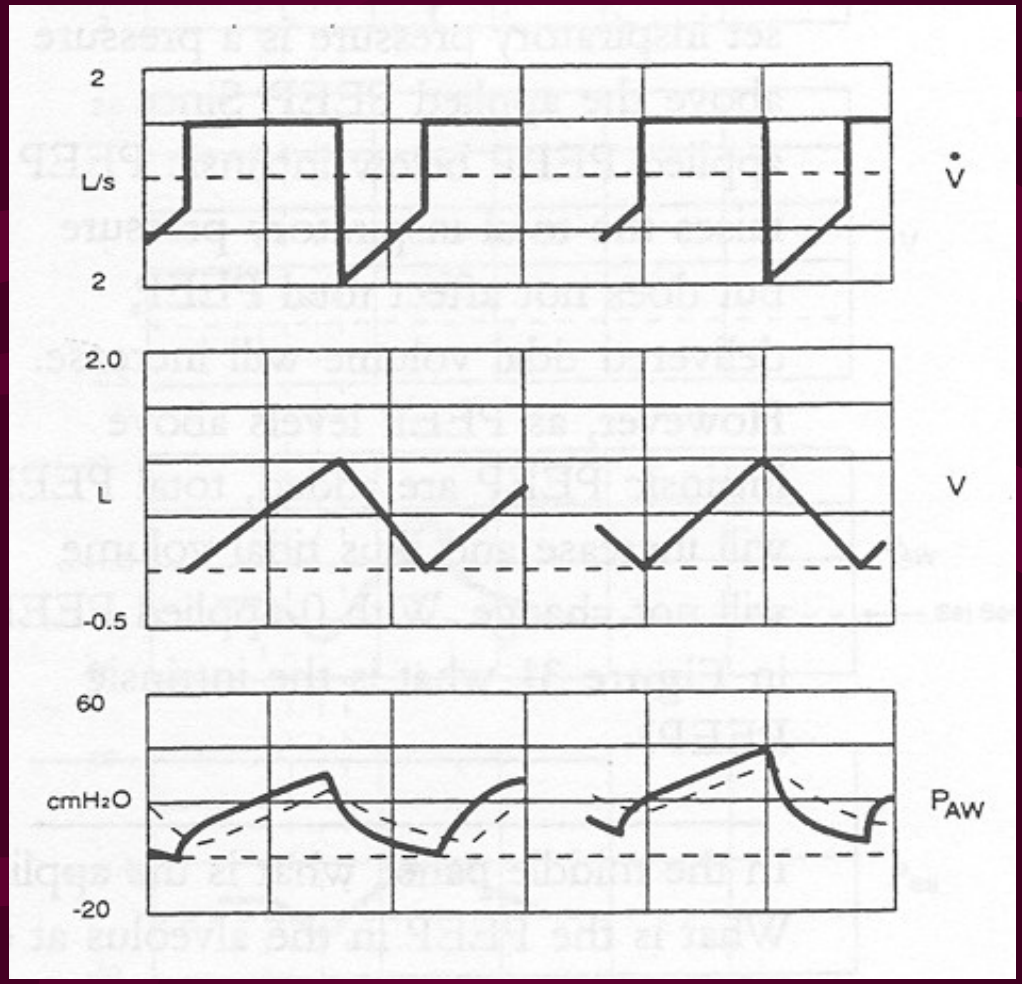
PEEP and Compliance

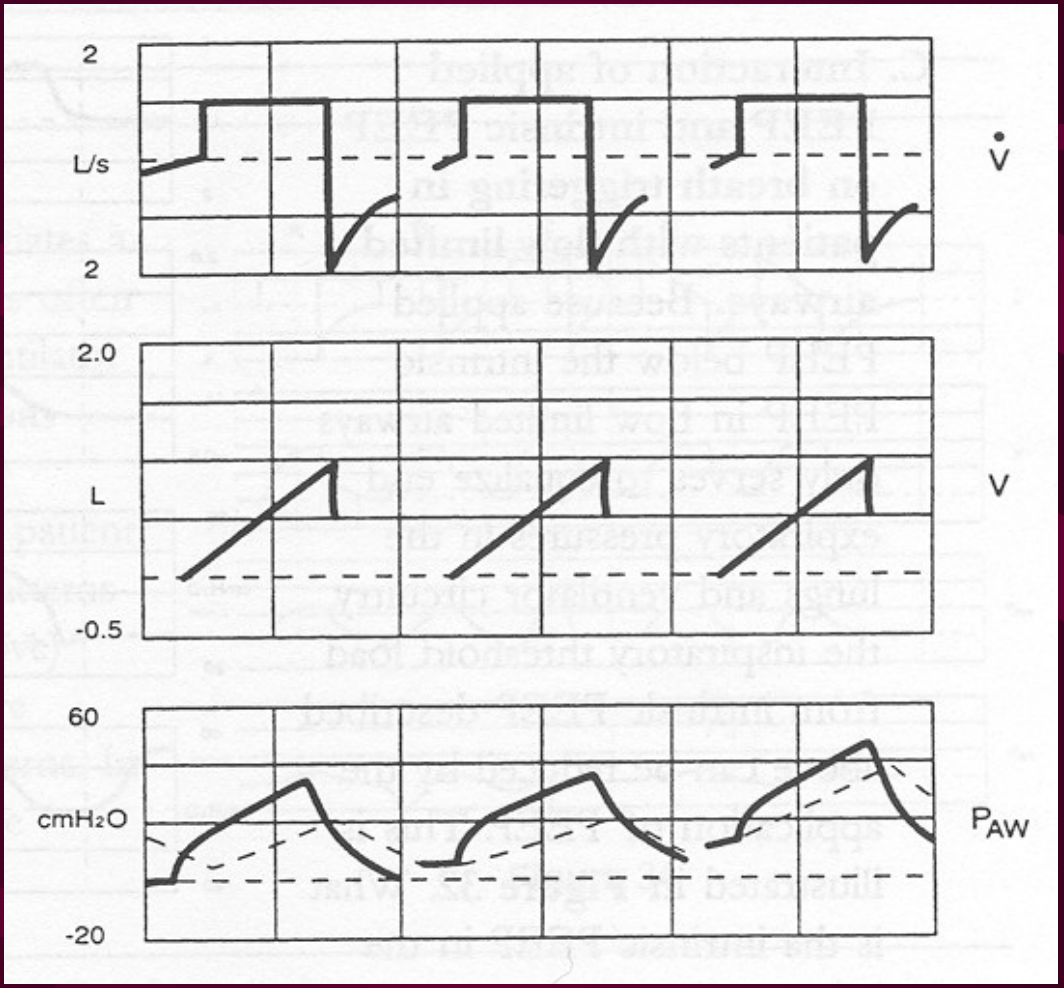


PEEP

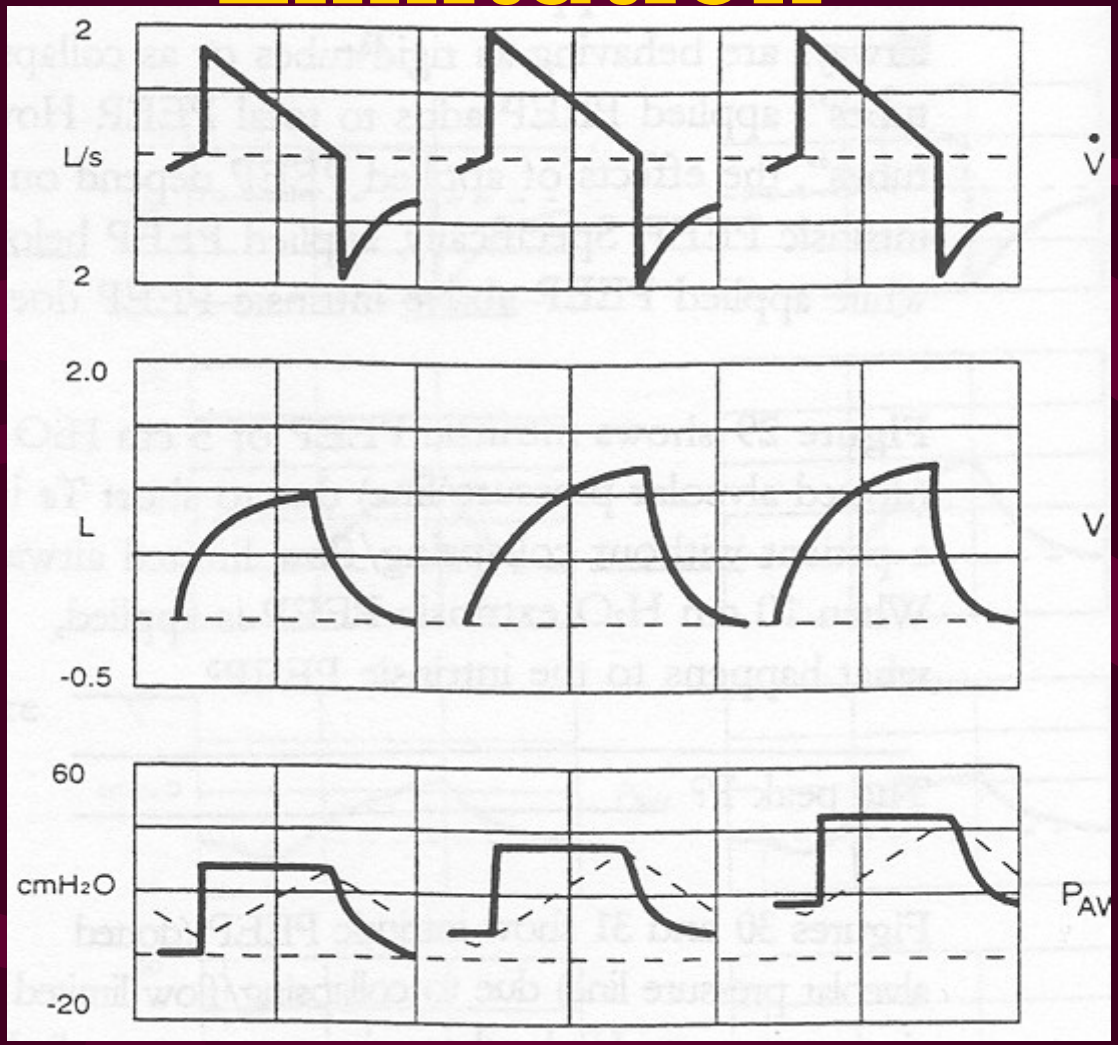
Interaction Between Applied and Intrinsic



PEEPi and Flow Limitation



PEEPi and Flow Limitation



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Patient Related Factors

- Anxiety
- Pain
- Secretions
- Bronchospasm
- Pulmonary edema
- Dynamic hyperinflation
- Abnormal respiratory drive
- Drugs
- Nutrition

Ventilator Related Causes

- Ventilator disconnection
- System leak
- Circuit malfunction
- Inadequate FiO_2
- Inadequate ventilator support

Ventilator Support

- Minute ventilation has a quadratic relationship to work of breathing
- Patient with increased drive, asynchrony may result from:
  - overly sensitive trigger
  - inadequate peak flow or peak flow rate
  - prolonged inspiratory time
  - inadequate pressure support
  - inadequate expiratory time

Background

- Total vs partial support
- Interactive modes can be either synchronous or asynchronous with patient efforts
- Synchronizing is important to avoid “imposed” muscle loading

Overview

- Mechanical breath parameters
  - breath triggering (trigger criteria)
  - ventilator delivered flow pattern (target criteria)
  - ventilator flow termination (cycling criteria)
- Imposed expiratory loads (ET tube, PEEP valve)
- “Backup” ventilator breaths (if not timed appropriately with patient efforts)

Breath Triggering

- Ventilator must sense a spontaneous effort to initiate flow
  - sensitivity (trigger phase)
  - responsiveness (post-trigger phase)
- Inherent asynchrony
  - pleural pressure change dampened
  - avoid “autocycling”
  - demand valve delay

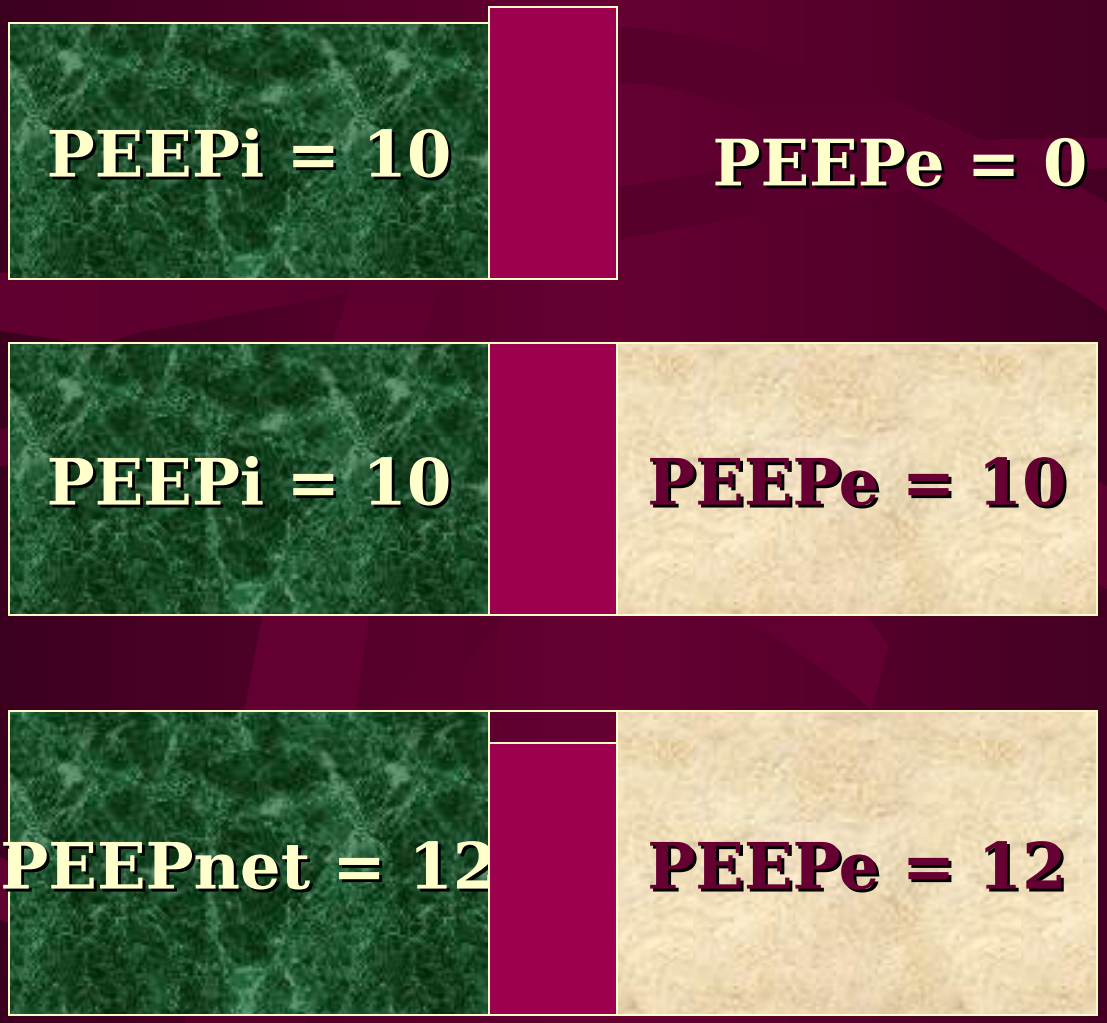
Breath Triggering
Minimizing Asynchrony

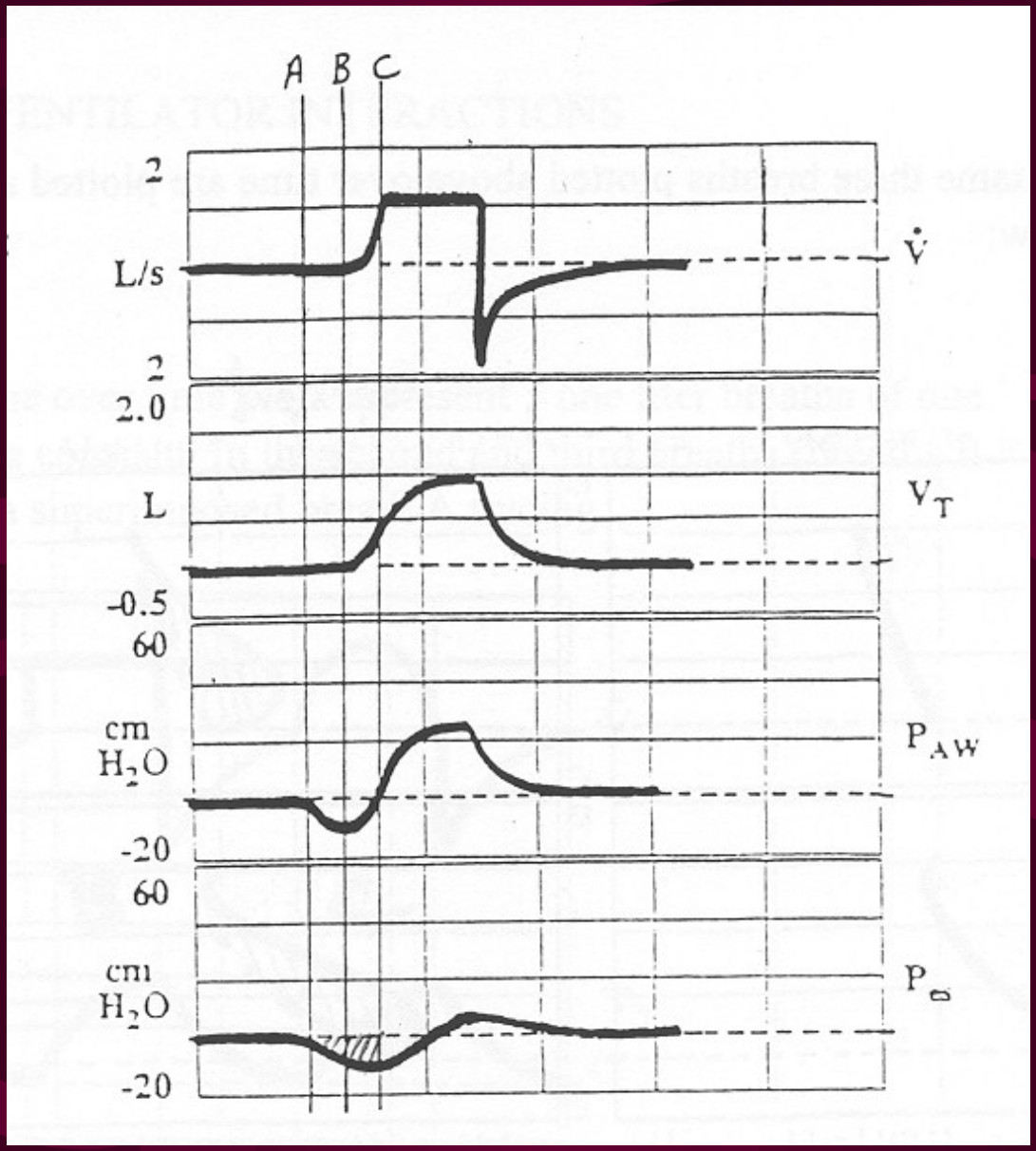
- Microprocessor flow controls
- Inspiratory pressure support
- Sensors in the pleural space or on the phrenic nerve
- Does the type of triggering matter?
  - Pressure
  - Flow

Auto-PEEP and Triggering

- In the setting of PEEPi, the elevated alveolar pressure at end inspiration can serve as a significant triggering load
- The addition of extrinsic PEEP may help with triggering, but will not affect the degree of hyperinflation

Auto-PEEP and Triggering

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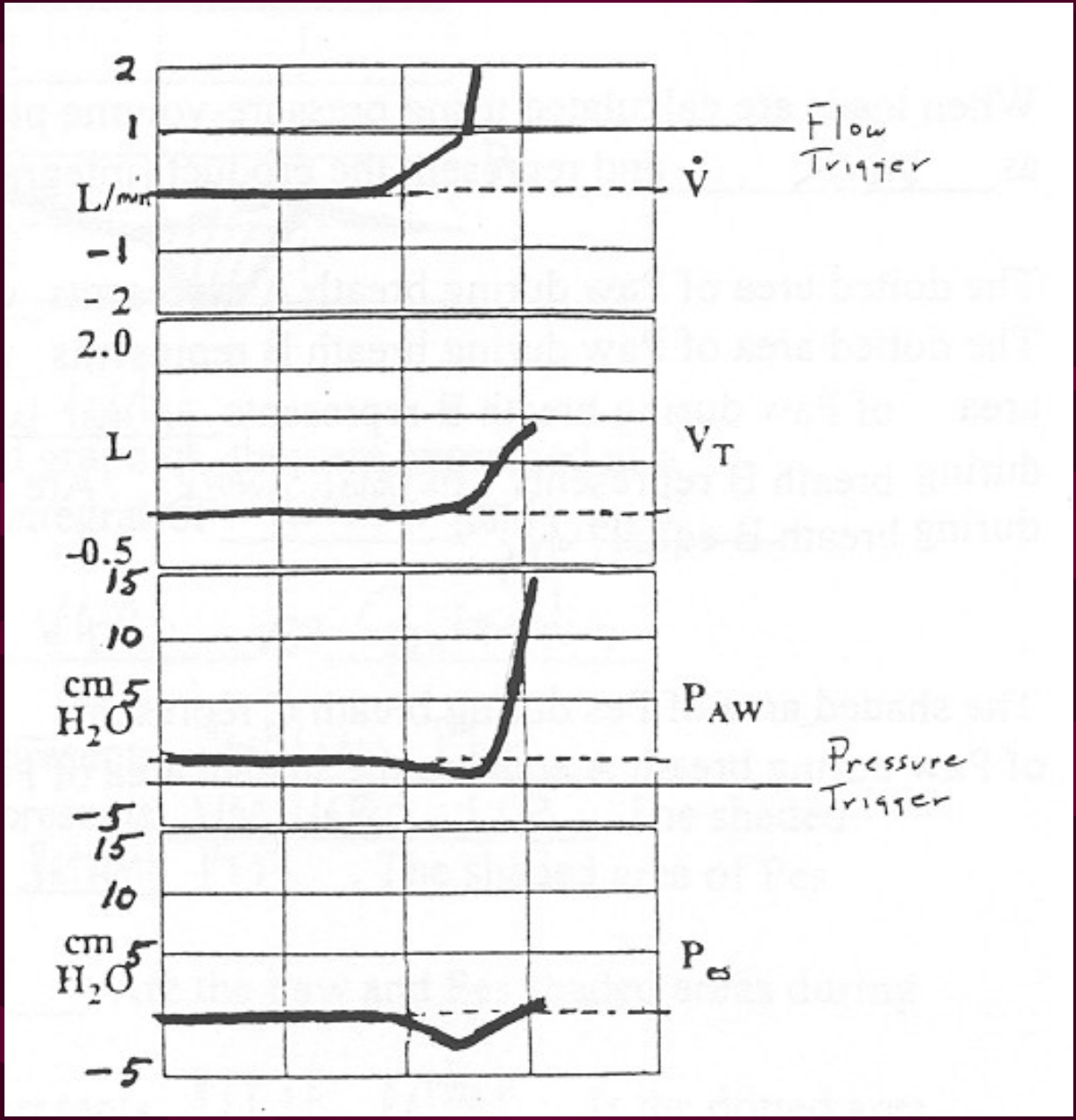
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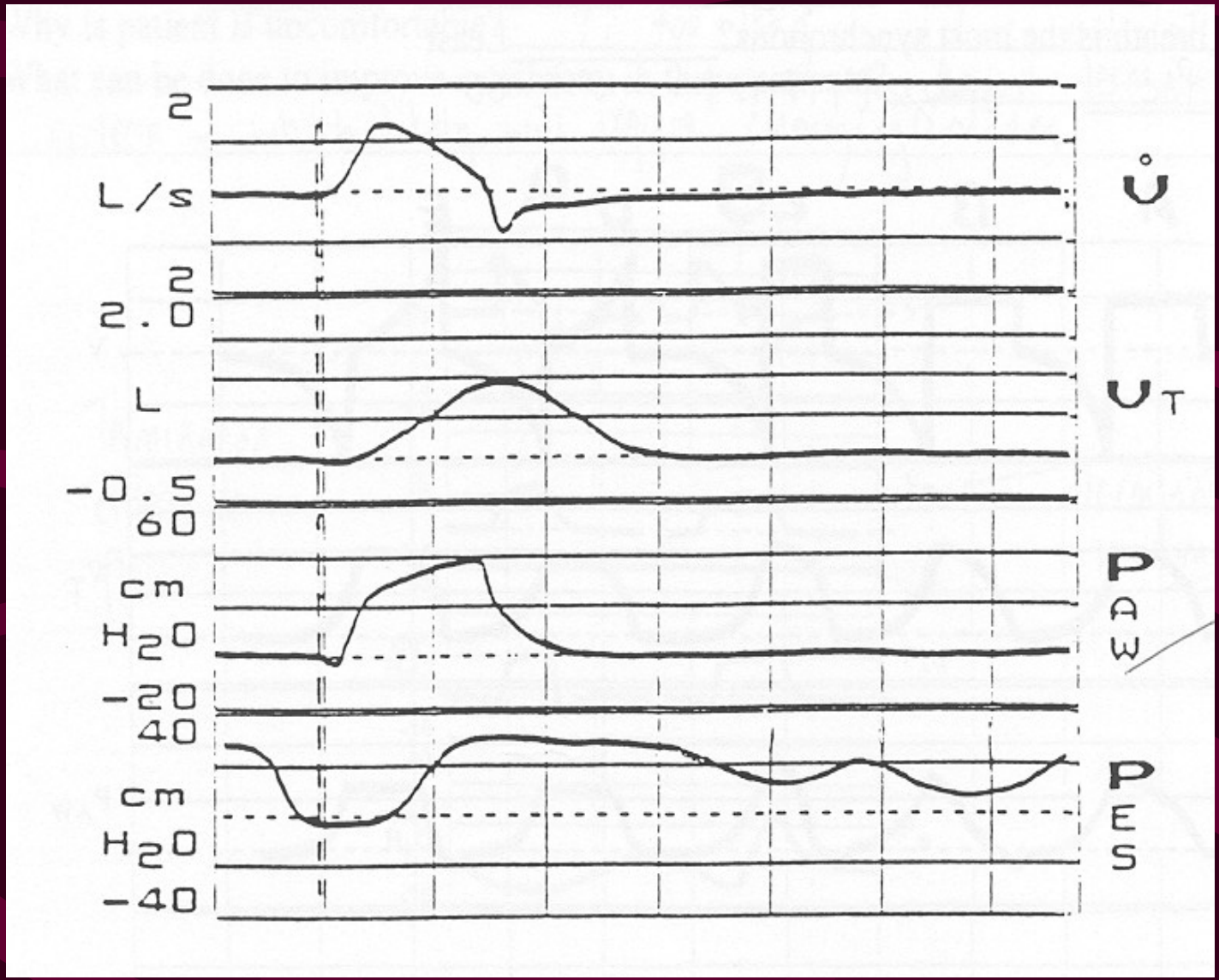
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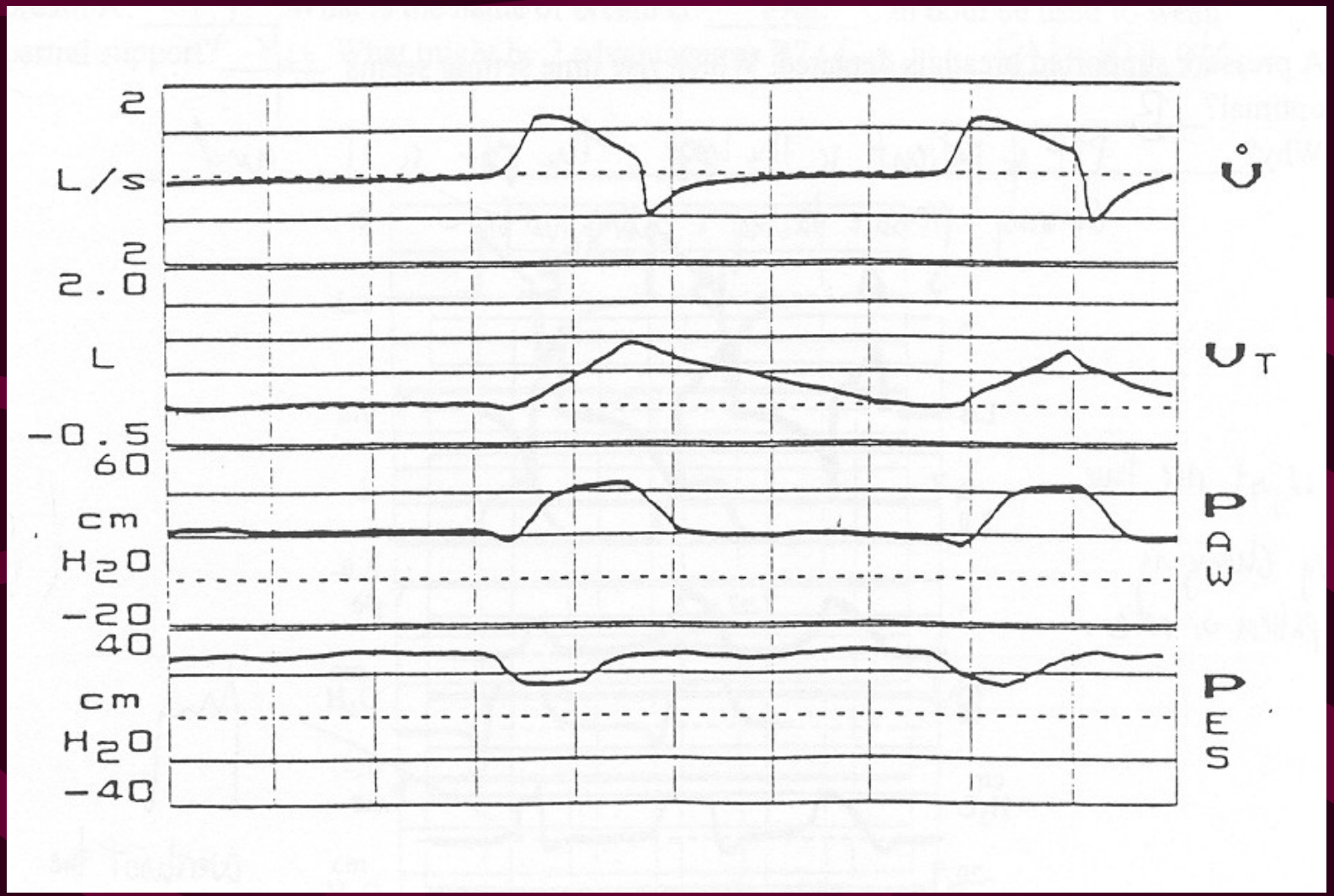
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Effect of Delivered Flow

- Interactive breaths can be “assisted”, “supported”, or “unassisted”
- Ventilator breaths can meet one of three goals after triggering
  - fully unload the ventilatory muscles
  - partially unload the ventilatory muscles
  - not affect ventilatory muscle loads

Effect of Delivered Flow

- Inadequate flow rates may cause the patient to sense “air hunger” and lead to greater work of breathing
- Flow rates exceeding demand are also poorly tolerated and can lead to increased ventilatory drives and “double cycling”

Fully Unloaded Breaths

- Goal is to deliver adequate flow over the entire inspiratory effort to unload the contracting muscles
- Assess by comparing the pressure pattern of a patient and machine triggered breath

Fully Unloaded Breaths

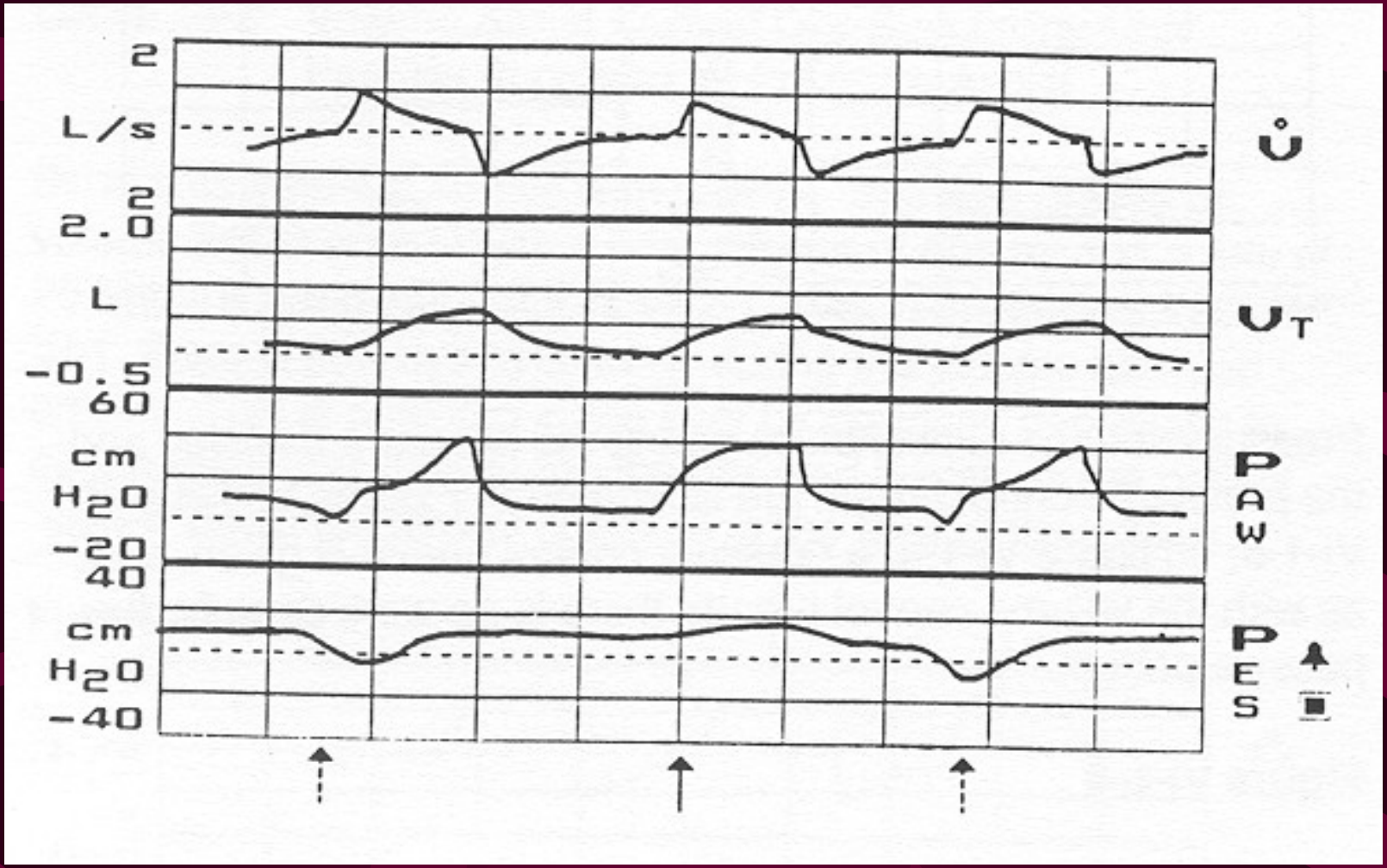
- Synchrony requires careful selection of flow rate and pattern
- Patients with high respiratory drives often require high initial flow rates
- Pressure targeted breaths may be easier
  - high initial flows
  - flow is continuously adjusted

Fully Unloaded Breaths

- Problems with pressure targeting:
  - patients with lower drives require lower flows
  - pressure target is the proximal airway… thus there is inherent under-responsiveness
- Studies comparing pressure and flow targeted breaths are lacking
- Proportional assist may be an alternative in the future

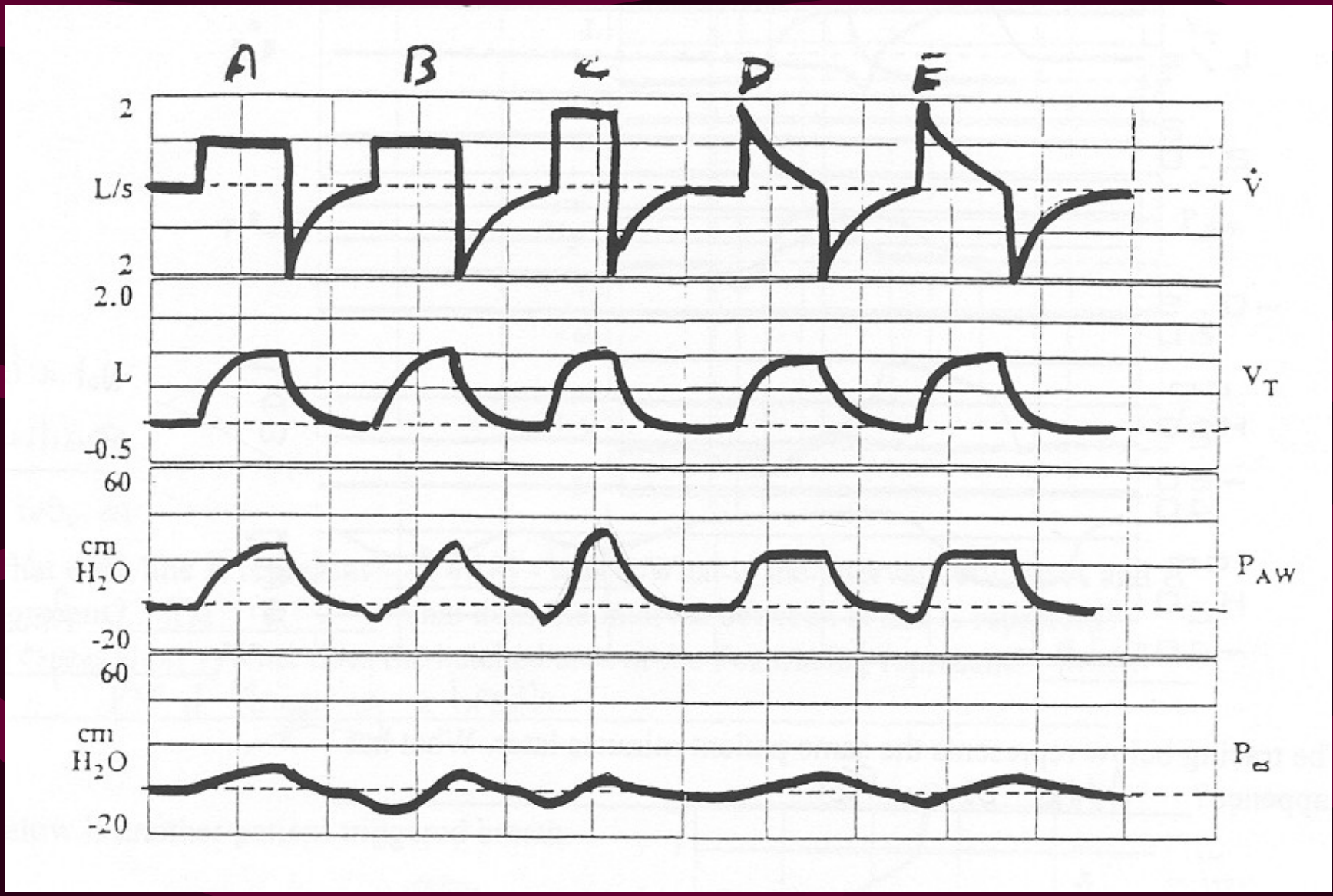
Breaths to Partially Unload

- Intermittently shift work between patient and ventilator
- Patient triggers the breath and then “shares” the work of the breath
- Studies directly comparing the two methods are lacking….though IMV tends to increase overall work done by the patient



Flow Dysynchrony in a Volume Targeted Breath

Flow Dysynchrony in a Pressure Targeted Breath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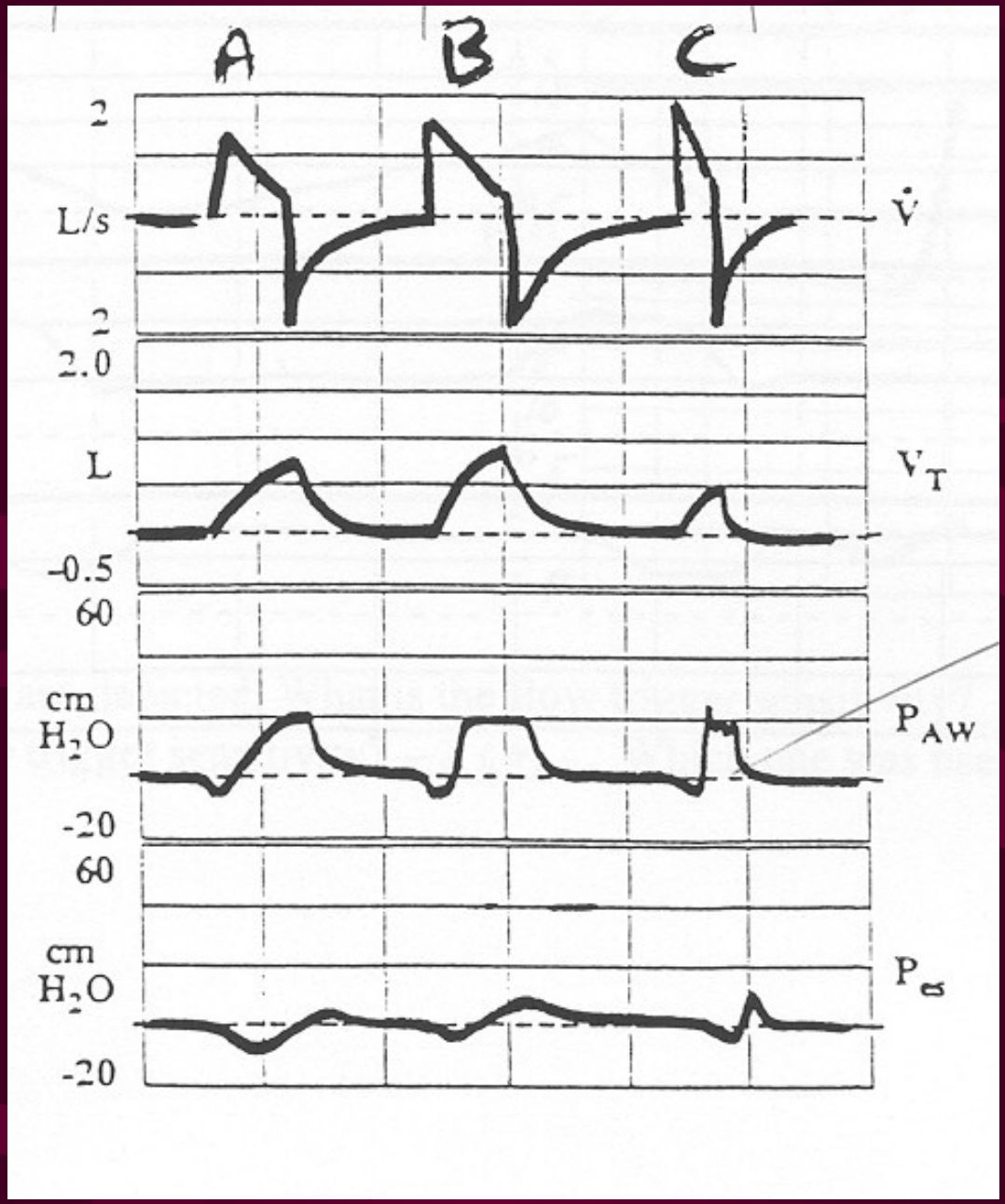
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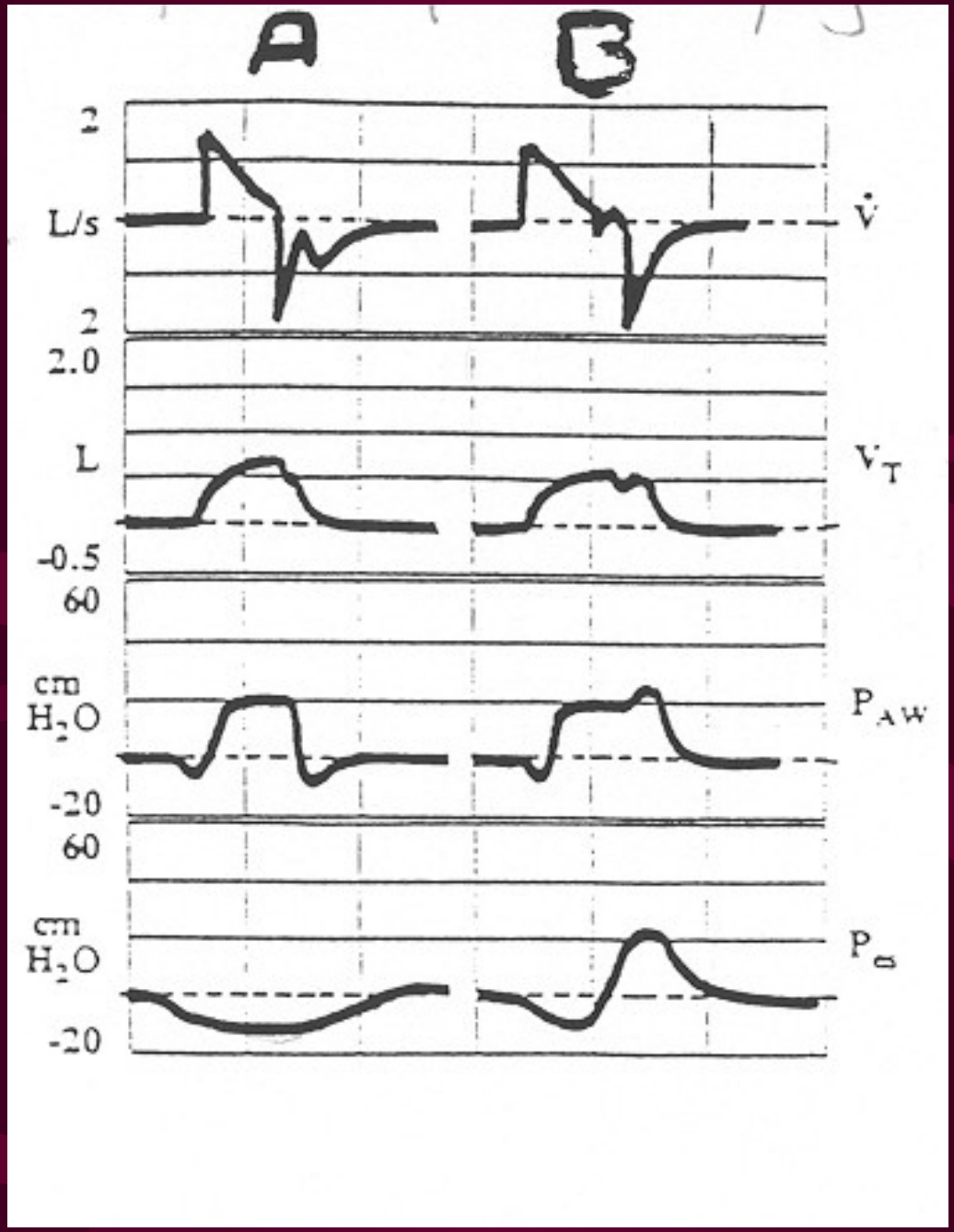
-20

Flow Termination: Cycling

- Cycling should be done in accordance with patient demand and adequate tidal volume
- Premature termination may lead to decreased tidal volume or inspiratory load
- Delayed termination may result in increased tidal volume or expiratory load

Flow Termination: Cycling

- With pressure targeted breaths, termination may be accomplished in several ways:
  - 25-30% of peak flow (duration and magnitude of patient effort can affect Ti)
  - PS level and rate of pressure rise can also affect Ti
  - Pressure assisted breaths….set Ti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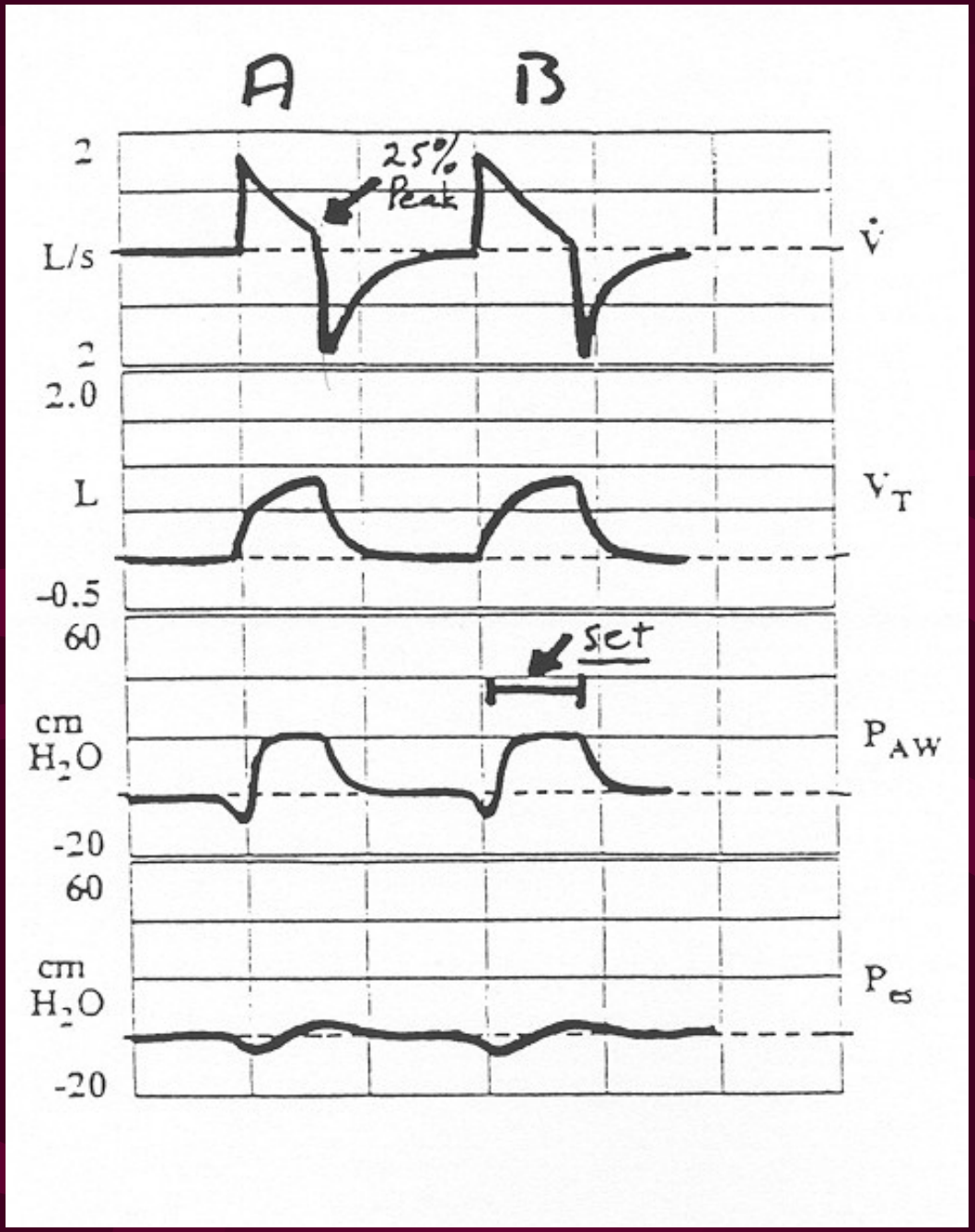
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Most Common Reasons for Dysynchrony

- ACV: Inappropriate flow settings
- IMV: Little breath-breath adaptation…as back-up rate decreases, WOB increases
- PSV: prolongation of inspiratory flow beyond patient's neural inspiratory time…this may also lead to PEEPi and triggering difficulty

- Patient comfort, synchrony with the ventilator is important to avoid imposed loads on the respiratory system
- Must consider trigger, flow, and cycling criteria when the patient “fights” the ventilator
- If problem unclear from the airway pressure tracing, consider placing an esophageal balloon

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